

Preface

The "Flight Testing Newton's Laws" NASA Education Series uses aircraft to stimulate the student's interest in the physical sciences and mathematics. The main emphasis lies in showing how Newton's three laws of motion apply to flight testing an aircraft. However, complementary areas of trigonometry, vector addition, weight and balance, along with resolution of forces are also employed. Following a brief review in the first video of Newton's Three Laws and the four basic forces of flight, the presentation follows the typical sequence employed by test pilots and engineers preparing for a test flight. Aircraft weight and balance, determining takeoff distance, cruise performance, and landing distance are addressed in turn.

Each lesson guide is presented in the format of a Flight Instructor's Manual used by aircraft manufacturers and pilots. This Manual contains certain areas where the teacher should direct the student's attention. Each of these areas are identified by their relative importance according to the following criteria:

NOTE: Sidelight information which may add to ensuing discussions but which is not considered essential to the material content.

Caution: Should the student fail to consider a particular aspect of the topic of discussion, the result may be the wrong answer to the example problem.

Warning: This block will identify background information the student should already possess. Knowledge of identified concepts is essential to understanding the material being presented. The material is not given during this session but is identified to the instructor in order to permit discussion of the material prior to undertaking the current lesson.

By way of example, consider the following:

NOTE: In an actual Pilot's Flight Manual, the Notes, Cautions, and Warnings are defined as follows:

NOTE: An operating procedures, techniques, etc., which is considered essential to emphasize.

Caution: Operating procedures, techniques, etc., which could *result in damage to equipment* if not carefully followed.

Warning: Operating procedures, techniques, etc., which could *result in personal injury or loss of life* if not carefully followed.

Often information that is not critical to flight safety, but which enhances the pilot's understanding, is provided in the form of an Operational Supplement. Throughout this manual, Operational Supplements are provided at the end of the session to enhance the understanding of the material. When appropriate, a note is added to direct the reader's attention to the end of session Operational Supplement.

All units in the Flight Instructor's Manual are presented in the English system. The rationale behind this is twofold. First, engineers and pilots in the United States still use the English system exclusively. All cockpits have instrumentation measured in feet, statute or nautical miles per hour, pounds per square inch, and foot-pounds. Second, it is felt that if so desired, by converting the example problems

into the metric system, the student will develop a feel for the relative magnitudes of units between the two systems. The accompanying text often presents both sets of units in its examples and explanations.

Occasionally, the teacher may want to stop the video to reinforce or clarify subjects being presented. Throughout this guide, there will be areas annotated by ****STOP VIDEO**** where clarification may be appropriate. In addition, where definitions are presented at the beginning of the session, it may be advantageous to review the definitions **before** showing the video. The recommended areas to start the video are annotated with ****START VIDEO****. All material presented prior to the ****START VIDEO**** symbol should be covered before hand.

The National Aeronautics and Space Administration's Education Division supports the National Education Standards. The activities in Flight Testing Newton's Laws were developed in accordance with the National Education Standards and satisfy the content requirements for science and mathematics specified below:

National Science Education Standards

Physical Science

Motions and Forces:

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.
- Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitation attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.

Curriculum Standards for School Mathematics

Mathematics as Problem Solving

- Use, with increasing confidence, problem-solving approaches to investigate and understand mathematical content.
- Apply integrated mathematical problem-solving strategies to solve problems from within and outside mathematics.

Mathematics as Communication

- Reflect upon and clarify their thinking about mathematical ideas and relationships
- Read written presentations of mathematics with understanding

Mathematics as Reasoning

- Make and test conjectures

Mathematical Connections

- Relate procedures in one representation to procedures in an equivalent representation

- Use and value the connections between mathematical and other disciplines

Algebra

- Represent situations that involve variable quantities with expressions, equations, inequalities, and matrices;
- Operate on expressions and matrices, and solve equations and inequalities;
- Appreciate the power of mathematical abstraction and symbolism;
- Demonstrate technical facility with algebraic transformations, including techniques based on the theory of equations.

Functions

- Model real-world phenomena with a variety of functions.

Trigonometry

- Explore periodic real-world phenomena using the sine and cosine functions;
- Solve trigonometric equations and verify trigonometric identities

References

NRC (National Research Council). 1996. *National Science Education Standards*. Washington, DC: National Academy Press.

National Council of Teachers of Mathematics. Commission on Standards for School Mathematics. 1989. *Curriculum and Evaluation Standards for School Mathematics*. Reston, Virginia: National Council of Teachers of Mathematics.

It is our intent that through the use of videos and Flight Manuals, the thrill of aviation can be enjoyed by both the student and the teacher.

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